Topic 8: Body Systems – 8a. Digestive System
8a1. Digestive Enzyme Lab (Spit Lab)

Resources:

Miller, K., Levine, J. (2004). *Biology.* Boston, MA: Pearson Prentice Hall.

Lactose Intolerance [Internet]. National Digestive Disease Information Clearinghouse, National Institute of Health. June 2009. Available from: http://digestive.niddk.nih.gov/ddiseases/pubs/lactoseintolerance/

Lactose Intolerance in Cats [Internet]. PetWave. 2009. Available from: http://www.petwave.com/Cats/Cat-Health-Center/Digestive-Disorders/Lactose-Intolerance.aspx

Building on:

The digestive system carries out both physical and chemical digestion. Physical digestion, like chewing, breaks food into smaller particles, increasing the surface area. Chemical digestion breaks macromolecules into their monomers so they can be transported via the circulatory and lymphatic system to the rest of the body. Chemical digestion is dependent on the use of enzymes to catalyze reactions by lowering the activation energy necessary for those reactions to take place.

Enzymes are specific and that is equally true for digestive enzymes. The first digestive enzyme that food encounters on its trip through the body is a carbohydrate, alpha amylase, in the mouth. Alpha amylase begins carbohydrate digestion by breaking starch into maltose units (two units of glucose bonded together). Alpha amylase works at an optimal pH of 7 and a body temp of 36.99 ^{o}C. This enzyme will be quickly denatured when it reaches the stomach with a pH of 2. Carbohydrate digestion will resume in the small intestine with different carbohydrases produced by the pancreas and the small intestine.

Links to Chemistry and Physics:

Catalyst
Activation energy
Organic chemistry
Polymers and monomers
Hydrolysis reactions

Stories:

Enzymes are critical to the functioning of the digestive system. If an enzyme is missing or in deficient supply, it can cause lots of problems. This is the case for many people that are lactose intolerant. They lack or have a very low level of an enzyme called lactase. Lactase is normally produced by the small intestine and it breaks down the disaccharide lactose, also known as milk sugar, into glucose and galactose (another monosaccharide similar to glucose). Without this enzyme, many people experience abdominal cramps, bloating, and diarrhea when they consume dairy products.

There are two main types of lactose intolerance. The first type, primary lactose intolerance, usually begins around the age of 2 and is progressive. Many do not experience symptoms until their late teens or early 20s. This type of lactose intolerance appears to be genetic, showing up with greater frequency in certain ethnic groups.

Secondary lactose intolerance is caused by injury to the small intestine. It may occur due to severe diarrheal infection or chemotherapy. There is no genetic connection with secondary lactose intolerance and it can occur at any age.

One of the ways lactose intolerance is diagnosed is by the hydrogen breath test. After fasting, the patient is given a solution high in lactose to drink. After consumption of the liquid the breath is collected and analyzed periodically for the presence of hydrogen. Normally, people have very little hydrogen gas in their exhaled breath. If a person is lactose intolerant and fails to break down the lactose in the small intestine, the lactose is hydrolyzed by bacteria in the colon, producing hydrogen gas. Some of this gas dissolves into the blood stream, is carried to the lungs, and is excreted in the exhaled breath.

Interestingly, a lot of cats are lactose intolerant. While kittens, they feed on their mother's milk, which is about 4% lactose, but as they are weaned, their lactase production diminishes by about 10%. The reduced amount of lactase in their body, along with the elevated amount of lactose (about 5%) in cow's milk, can make them sick to their stomach or have diarrhea when they drink that bowl of milk that everyone thinks they need. Note, however, that some cats never show any symptoms.

Materials for the Lab:

- Matzo crackers (unsalted); it takes about two pieces, each the size of a saltine for each group.
- Funnels
- Filter paper
- Test tubes
- Hot plates
- Iodine dropper bottles
- Benedict's solution dropper bottles
- pH paper
- Hot plates
- Beakers for warm water (just a little bit warmer than room temperature)
- Beakers for boiling water on the hot plates
- Test tube holders

Instructions for the Teacher:

You will need to go back over the test for starch and for glucose. Demonstrate the starch test with a little starch water (water that has had spray starch added) and a couple of drops of iodine; it should turn dark blue black. Pure water with the iodine stays amber. Leave these out on a front table for the students to refer to during the lab.

Review the test for glucose (and maltose), the Benedict's test. Take a little water into which you have dissolved some glucose (also known as dextrose) and add enough drops of Benedict's to turn it a pretty aqua. Lower the test tube into boiling water for a minute. If it turns green, that mean there is a little glucose present; if it turns orange, there is a lot of glucose present. Pure water with Benedict's will stay aqua even after boiling.

When the students filter both the cracker crumbs and the chewed cracker, it is not important to wait until all of the filtrate goes through. As soon as they have enough filtrate to put a ml or so in each testing tube, they can carry out the starch and the glucose tests.

It is hard to chew without swallowing; emphasize that they have to do this for two minutes! Tell them they can cover the filter paper if they don't want anyone to see the yucky, chewed cracker.

Digestive Enzyme Lab (Spit Lab)

Introduction: Enzymes catalyze reactions that normally would not take place fast enough at normal body temperature. Specific enzymes catalyze specific reactions. Digestive enzymes help break food molecules into simpler substances so that they can be utilized by the body. Starch is a large polymer molecule made of many glucose subunits. Maltose is a disaccharide made of two glucose subunits.

Procedure:

1. Fold a piece of filter paper and put it in the funnel. Place the funnel in a test tube.
2. Crush a piece of matzo cracker into tiny, tiny pieces and place them in the filter paper that is in the funnel.
3. Pour 10 ml of warm water over the cracker pieces and collect the filtrate in the test tube.
4. Divide the filtrate into two test tubes. Test tube #1 for the presence of starch. Record your results on the Evidence Table. Test tube #2 for the presence of glucose. Record your results on the Evidence Table.
5. Using pH paper, test the pH of your saliva. Record this on the Evidence Table.
6. Assuming that your normal body temperature is 98.6 degrees F, what would your temperature be in Celsius? Record this on the Evidence Table.
7. Clean the funnel and the test tubes. Throw out the old filter paper.
8. Put a new piece of filter paper in the funnel.
9. Have one member of your lab group chew some matzo cracker for two minutes without swallowing. Put the chewed cracker into the filter paper in the funnel.
10. Pour 10 ml of warm water over the chewed cracker and collect the filtrate. Divide this between two test tubes.
11. Test the divided filtrate for starch and for glucose. Record your results on the Evidence Table.
12. Rinse and clean all test tubes and the funnel. Throw away used filter paper. Wipe off the lab table.

Evidence Table

	Test for Starch		Test for Glucose	
	Color	Pos. or Neg.	Color	Pos. or Neg.
Crushed cracker				
Chewed cracker				
Saliva pH =				
Body temp in ^{o}C =				

Analysis Questions:

1. Describe the reaction that is catalyzed by saliva.

2. If you had eaten a food high in protein and very little carbohydrate in it, how would your results have changed?

3. What is the pH of your stomach?

4. The enzyme in saliva is called **alpha amylase**. What do you think happens when the alpha amylase enzyme gets into your stomach?

5. What problems would you anticipate in a person that is unable to produce alpha amylase in their saliva?

6. What type of digestive enzymes are present in your stomach? In your intestines?